REMOVAL ASSESSMENT REPORT
FOR
RED AND BONITA MINE
SILVERTON, SAN JUAN COUNTY, COLORADO

Prepared for:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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CR	County Road
DRMS	Colorado Division of Reclamation and Mine Safety
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERRS	Emergency and Rapid Response Services
gpm	gallons per minute
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
SPI	Secondary Permeability Index
START	Superfund Technical Assessment and Response Team
TCLP	Toxicity Characteristic Leaching Procedure
TDD	Technical direction document
UOS	URS Operating Services
USGS	U.S. Geological Survey
WESTON	Weston Solutions, Inc.

1 INTRODUCTION

The United States Environmental Protection Agency (EPA) tasked the Weston Solutions, Inc., (WESTON®) Superfund Technical Assessment and Response Team-4 (START) under Technical Direction Document (TDD) 0001/1306-05 to provide technical support for a removal assessment at the Red & Bonita Mine site (Site) near Silverton, San Juan County, Colorado. Assessment included mine entries during 2013 and 2014 to characterize the workings of the Red and Bonita Mine. The Red and Bonita Mine discharges approximately 300 gallons per minute (gpm) of mine impacted water that impacts water quality in Cement Creek and downstream waters. The mine is being investigated to determine potential means of reducing the impacts of the mine to downstream waters.

During 2013, the Red and Bonita tunnel was mapped and the mine geology and hydrogeology were characterized. During 2014, a packer test was performed to determine the suitability of a potential bulkhead location. Support activities included air monitoring, mine ventilation, water and solids management, and water sampling.

This report describes the mine entries, evaluation methods and results, support activities, and analytical results from the 2013 and 2014 site work. Section 1 is a brief description of the objective and scope of the removal assessment, Section 2 provides a brief description of the site and its known history including EPA work performed during 2011 and 2012, Section 3 describes 2013 and 2014 assessment activities, Section 4 describes the packer test and results, Section 5 describes water and solids management setups for 2013 and 2014, and Section 6 describes sampling and analysis. Photos are presented in Appendix A, supplemental water and solids management information is provided in Appendix B, Division of Mining Reclamation and Safety reports are presented in Appendix C, and packer test background and procedure are presented in Appendix D. Laboratory analytical reports are provided in Appendix E.

2 SITE BACKGROUND

2.1 SITE DESCRIPTION

The Red and Bonita Mine is located in San Juan County, Colorado approximately 7 miles north of the town of Silverton (37.897302 north and 107.643883 west) (Figure 1). The portal elevation is 10,893 feet above mean sea level. Road access is via County Road (CR) 110 from the town of Silverton to CR53 at the abandoned town site of Gladstone. CR53 continues northward up the Cement Creek valley to the mine site, approximately ¾ mile north of Gladstone. The site lies east of Cement Creek on a west-facing mountainside slope with an average 44 percent grade. The mine is accessible during non-snow months of the year, typically late June through early October.

The Red and Bonita Mine site consists of a 1.25 acre waste rock dump and an estimated 3500 feet of mine workings that drain approximately 300 gallons per minute (gpm) throughout the year. Adit discharge flows across a work pad at the top of the mine dump and approximately 200 feet down the waste rock/tailings dump face before being channelized at the toe of the dump. The channel directs flow into an iron bog en route to Cement Creek approximately 500 feet downgradient of the toe of the dump. Cement Creek enters the upper Animas River watershed in Silverton. The Animas River and many of its tributaries, including Cement Creek, carry high concentrations of metals from both acid rock/mine drainage at mine sites and from natural sources not impacted by mining. Water quality studies have indicated that the Red and Bonita Mine is one of the major sources of metals to the Animas River near Silverton. Several other mines in the Cement Creek basin above Gladstone also have draining adits, including the Gold King Level 7, the Grand Mogul, and the Mogul mines.

2.2 SITE HISTORY AND PREVIOUS ASSESSMENTS

Mining began near Silverton in 1871 and lasted until as late as 1991. Historic mapping of the Red and Bonita Mine indicates that it was advanced predominantly prior to 1899. Mining operations lasted a short period but no activity occurred after the initial operations, which apparently ceased within a few years. Additional information regarding mining in San Juan County is provided in the National Register of Historic Places.

Multiple agencies and organizations, including EPA, have been monitoring water quality, contaminant loading, and the resultant risks to human health and the environment in the Animas River watershed since the early 1990s. The Animas River Stakeholders Group (ARSG) formed as an ad hoc watershed group to work on various projects related to the mining impacts to the river. Over a period of approximately 20 years, the group has participated in various projects to manage mine waste and to reduce the flow of contaminated water from a few mines in the watershed. In addition, under the terms of a consent decree with the State of Colorado, Sunnyside Gold Mine Company performed several large scale projects related to historic operations on properties associated with the company's operations. One project was plugging (installing concrete bulkheads) within the Sunnyside mine workings, including the American Tunnel, during the period from 1996 to 2002. The American Tunnel is located in Gladstone, approximately ¾ mile south of the Red and Bonita Mine. During the mine operation, the American Tunnel discharged approximately 1,700 gpm of metal laden water and was treated prior discharging to Cement Creek. Following the installation of the last of the three plugs, flow from the American Tunnel has decreased to approximately 100 gpm, the result of leakage around the concrete bulkhead.

The flow from the Red and Bonita Mine, the Gold King (Level 7) Mine, and the Mogul Mine all experienced significant increases in flow following the plugging of the American Tunnel. Since bulkhead installation, the Red and Bonita discharge rate has increased from negligible to over 300 gpm. The pH of discharge water typically measures between 5 and 6. The pH decreases significantly when metal oxy-hydroxide sediments and precipitates are stirred up by activities within the mine. Contaminants include low pH and metals. Cadmium concentrations from the mine discharge ranged from 33.3 micrograms per liter (µg/L) to 39.3 µg/L, copper concentrations ranged from 4.5 µg/L to 50.6 µg/L, iron concentrations range from 76,700 µg/L to 97,600 µg/L, lead concentrations ranged from 34 µg/L to 71.2 µg/L, and zinc concentrations ranged from 13,600 µg/L to 17,500 µg/L. Additional information regarding the Animas River watershed in San Juan County is provided in scientific papers that were compiled by the U.S. Geological Survey (USGS) (Church et al 2007).

2.2.1 2010 and 2011 Mine Work

The mine water discharge occurred through a collapsed rock debris blockage for an unknown number of years. The following work was performed to investigate and open the mine tunnel (URS Operating Services (UOS) 2012a).

- A groundwater monitoring well was drilled into the Red and Bonita tunnel in September 2010. A pressure transducer was installed to measure temperature, conductivity, and static water levels and to provide insight into conditions of the pool of water backed up behind the portal blockage in anticipation of removing the blockage the follow year.

- The north road used to access the portal area was improved. The work area at the top of the waste rock dump was improved by placing 1-inch to 12-inch rock debris over solid precipitates that armored the pad, covering the surface with geotextile, then adding a 6- to 12-inch layer of talus material.

- Diversion channels were constructed to divert adit flow as necessary for operations including allowing it to flow its natural course over the dump or into piping to manage the discharge during underground work. A sump was excavated near the mine portal to allow the flow to be captured in a pipe and allowed to either flow down the face of the waste rock pile during inactive work periods or into piping during active work periods.

- During excavation of the blockage and underground work, water discharged from the mine was routed from the sump to filter bags placed on the work pad at the base of the waste rock dump to collect any solids. As necessary during the blockage removal, the pooled water was pumped from behind the blockage into 6-inch PVC piping to four filter bags connected with a manifold system at the toe of the waste rock dump. Liquid aluminum sulfate flocculant was added to water at a rate of 30 to 100 gallons per day. An additional filter bag was placed at the outfall of a culvert pipe under CR53.

- A 10 foot diameter and 10 foot long corrugated galvanized metal pipe was installed at the portal structure and a secure metal barrier with a locking door was added to restrict access. The portal structure was built into a mostly competent ferricrete mass entering the tunnel.

- A limited investigation of the mine was conducted, but in-mine work was abandoned when monitoring indicated inadequate oxygen in the air. No toxic gasses were detected.

- Review of historic mining information and aerial photographs did not show other openings into the mine, and this was partially confirmed in that air did not appear to be moving through the mine.

2.2.2 2012 Mine Work

The workings in the Red and Bonita Mine were investigated and mapped during a June 2012 mine entry (URS Operating Services, Inc. (UOS) 2012b). The following work was performed during 2012:

- The rock structure and water sources entering the workings were evaluated to determine the potential for implementing hydraulic controls. The underground assessment work was performed by a team including mining engineers and a geologist with the DRMS, supported by EPA.

- An attempt was made to confine flow into flexible pipe using a series of sandbag coffer dams constructed in the first hundred feet mine to slow the flow of water and allow the sludge to accumulate. This proved unsuccessful as a means of reducing the discharge of solids.

- The investigation of the first 680 feet in the mine tunnel indicated the following:

  1) The first 680 feet was open without blockages/collapses;

  2) The tunnel is in a competent andesitic rock requiring little to no support;

  3) 0.5 feet to 3 feet deep sludge covered the entire 680 foot distance. The extent and depth of the precipitate contributed to waist-deep mine water in some areas, making mine entries difficult.

- A water inflow of approximately 10 gpm was observed from a small drift located at approximately 283 feet into the tunnel, while the remainder of the approximate 300 gpm flow was from beyond 680 feet.

- Approximately 2 to 3 feet of solid precipitates was present in the mine. Solids were mobilized and released from the mine when people walked through the sludge during mine entries. The solids content in the flow exiting the mine increased significantly when the settled solids in the tunnel were disturbed during mine entries; therefore, water discharged during mine entries was directed through filter bags prior to discharge toward Cement Creek. Flocculant (alum) was added to assist in the solids settling/filtration rate, which was somewhat improved. It was noted that while the adit discharge water pH typically ranged from 5 to 6, the pH decreased to between 2 and 4 during mine entries.

- In-mine work ceased when the maximum capacity of the filtration system was reached and expansion for additional filter bags was not feasible at that time. Construction of a settling pond was not an option until later when access was granted by the adjacent landowner.

- The filter bag solids were dried and sampled. Toxicity Characteristic Leaching Procedure (TCLP) analytical results indicated that the solids did not exceed Resource Conservation and Recovery Act (RCRA) hazardous waste limits (Table 1, from UOS 2012). The spent filter bags from 2011 and 2012, containing an estimated 5 to 7 tons of mine drainage filtrate, were transported to the Bondad Landfill in Durango, Colorado, for disposal in July 2012.

Subsequent to the entry in June 2012, the owner of the Success Placer claim on the west side of CR53 opposite the Red and Bonita waste rock dump agreed to allow access for EPA to construct a settling pond to assist in capturing the solids in the discharge water. The area was evaluated prior to pond construction. Mill tailings observed on and below the ground surface, possibly from a stamp mill that operated at the mine, had elevated metals concentrations: iron (437,000 to 444,000 mg/kg), lead (1,500 to 1,800 mg/kg), and zinc (1,200 to 1,500 mg/kg). Mercury was detected in a surface sample. The settling pond was excavated in October 2012.

3 REMOVAL ASSESSMENT

3.1 REMOVAL ASSESSMENT – 2013

EPA conducted mine entries and support activities from August 5 to August 15, 2013 to map the mine, evaluate the rock conditions, identify inflows of water and collect mine water samples. Construction work outside the mine was performed by Environmental Restoration (ER), EPA's ERRS contractor. Underground mining support work was performed by Frontier Environmental. The water and solids management system was operated by ER and START personnel. DRMS, EPA, and Frontier Environmental performed the mine investigations.

3.1.1 Underground Mapping and Preliminary Bulkhead Siting Evaluation

The primary objective during this phase of the assessment was to determine where water inflows originate, examine the extent of the workings to the degree possible, and determine if any connections to other mines were present. The accessible workings were limited to approximately 2000 feet of an estimated 3500 feet. The following work was performed during 2013:

- Site Preparation

- The water diversion arrangements on the waste dump outside the portal were modified to provide better control of the discharge from the mine. The existing 8-inch pipe was removed and the 14-inch pipe was repositioned to capture all of the mine water from the retention pond and direct it to the edge of the waste rock dump, doubling the work area and sealing the work pad from leakage.
- The roadside drainage ditch along CR53 was improved to increase the freeboard in the ditch and prevent road damage from water from flowing over CR53.

- Mine ventilation system installation
  - In-mine oxygen levels exceeded 19%, the minimum level for safe work conditions, prior to ventilation during previous mine entries. However, ventilation with the fan and previously hung sections of vent bag duct system was performed for a period prior to the initial 2013 entry. A series of vent bags were connected and hung from the walls of the tunnel using spads. The vent bags were extended to 600 feet into the mine and remain in place for future work.
  - A high volume (10,000 cfs) electric fan was used for ventilation during mine entries. The diesel generator used to power the fan was placed away from the portal to prevent carbon monoxide intake to the fan.
- Removal of in-mine solids retention dams from 2012
  - In-mine solids retention dams (sandbag dams) previously installed to reduce solids discharge during mine entries were removed to improve work safety conditions.
- Water and solids management system installation (See Section 5 and Appendix B for details)
  - A piping system was installed to direct water from the portal pool down the waste rock dump and under CR53 to the settling pond.
  - Chemical feed tanks, pumps, tubing, injection ports, and in-line "mixing" zones were installed in the piping for addition of sodium hydroxide, LBP polymer, and Chitosan flocculant to enhance solids settling in the settling pond.
  - Filtration systems
    - A multi-media / canister filtration system was installed to provide additional solids removal.
    - Filter bags were available as a contingency for when the multi-media filtration system was not used or did not adequately remove solids from the water. This proved unnecessary during the period of operations in 2013.
- Water and solids management system testing and operation (See Section 5 and Appendix B for details)

- During the entry work and ventilation bag set-up, it became necessary to remove a portion of the solids precipitates to create a channel to walk in while underground. This added to the volume of the solids to manage.

- Testing

  - Preliminary settling tests and pH titrations were performed to estimate chemical requirements and initial chemical feed rates.

  - Field bucket tests were performed to optimize feed rates to enhance solids settling.

- Filter bags (15-foot x 15-foot) were attached to culverts that passed under CR53 to collect sediment if discharged during the work pad improvements and drainage channel clearing efforts.

- Water was directed to the system prior to the start of mine entries each day to charge the system and ensure proper function.

- pH and settling characteristics were monitored and chemical injection rates were adjusted as needed to account for variations in water quality when in-mine work activity changed.

- Water samples were collected from the portal pond and the filter discharge point (see Section 6).

- After the effects of the mine entry ceased each day, water was directed back to the historic flow path down the face of the waste rock dump.

- After the last mine entry for 2013, approximately 800 to 1000 cubic feet of solids were left in the ponds to dry. A solids sample was collected from the bottom of the pond after the water was pumped off (see Section 6).

- Mine assessment

  - The mine was mapped and characterized to a point approximately 980 feet into the mine on the main cross-cut. Two larger drifts were also inspected and mapped, each several hundred feet as shown on Figures 2 and 3. The results are presented in Section 3.1.2.

  - Mine water was sampled from the primary flows from the drifts and along the main cross-cut and samples were sent to a laboratory for analysis (see Section 6).

  - In-mine personnel monitored oxygen and carbon monoxide levels during mine entries.

- Post-assessment cleanup

  - A 25-foot square, 4-foot deep temporary repository was installed at the north end of the base of the waste rock dump east of CR53. The cell was lined with geotextile and spent filtration bags.

- Solids were removed from the south cell of settling pond and placed at the toe of the waste rock dump within a cell constructed for those solids. Solids from the north and central settling pond cells were left in the pond to dry over the winter because the water content was too high for efficient removal.

- Temporary piping used to convey flow to the pond was removed. Any disturbance to the county road was graded and fill was added as needed (September 2013).

3.1.2 2013 Mine Investigation Findings

The following findings resulted from the 2013 mine investigation (DRMS 2014a [provided in Appendix C] and mine maps). Two maps prepared by personnel conducting the mine entries are presented as Figures 2 (DRMS map) and 3 (Bockstiegel map).

- The Red and Bonita mine workings (main cross-cut and multiple drifts) were mapped. A collapse and precipitation build-up prevented further entry at approximately 980 ft in from the portal on the main eastward heading. Approximately 2000 feet of workings were assessed.

- The portal of the Red and Bonita adit is faced-up in ferricrete, and the adit is then driven through Burns Member rhyodacite of Silverton Volcanics Formation.

- The first major drift occurs at 275 feet into the tunnel, with approximately 40 gpm to 50 gpm flow from the drift into the main tunnel.

- The drift at 275 feet extends to a distance of 940 feet from the portal. A secondary drift at 640 feet from the portal along the 275 drift ends at a caved in area.

- The tunnel splits at 362 feet into the tunnel, with the primary tunnel veering left; the straight segment dead ends and only contains stagnant water (no inflow to main tunnel).

- A stub drift is present 452 feet into the tunnel.

- The main tunnel is timbered between 590 and 650 feet into the tunnel. Some loose rock was observed on the left rib.

- A drift veers left at 764 feet into the tunnel. The drift extends to 1158 feet in from the portal and contributed approximately 20 gpm to the tunnel discharge.

- The main tunnel was evaluated to a point 980 feet in from the portal. The main tunnel past 764 feet contributed approximately 200 gpm to the tunnel discharge.

- A stope and stulls are present in the main adit heading east past 764 feet.

- A collapse that impounds a pool of water is present at 980 feet into the main tunnel. The mine can be accessed beyond this point but wasn't entered during 2013 to prevent uncontrolled release of water from behind the dam and to protect worker health and safety.

- A potential bulkhead location was identified at 265 feet into the tunnel. This location is outby the first primary drift at 275 feet that contributed 40 to 50 gpm of water during the 2013 mine mapping.

3.2 REMOVAL ASSESSMENT - 2014

A packer/hydraulic conductivity test was performed the week of September 8, 2014 to help determine the hydraulic properties of rock at the potential bulkhead location identified by EPA and DRMS during previous mine entries. Construction work was performed by ER. Water treatment testing and operation was performed by ER and START. Miners from Maisel Construction drilled boreholes for the packer test. The packer test was performed by DRMS, EPA, and START with support by ER.

Work conducted at the site during 2014 included the following:

- A mine water sample was collected from the portal pool and titrated with 25% sodium hydroxide to estimate the amount of sodium hydroxide required to increase the pH to range between 6 and 7. Settling tests were performed to determine the optimum Brennfloc flocculant addition rate.

- Solids left in the settling pond from the 2013 mine entries were removed with shovels and an excavator and placed in the temporary repository. Geotextile disturbed during excavation was repaired. Straw bales and staked silt-fence were used to increase the elevation of the baffles between settling pond cells.

- Packer tests were conducted in each borehole. See Section 4 for more information regarding the packer test and test results.

- The water and solids management system for 2014 included sodium hydroxide addition, free flow down the face of the waste rock dump, pH measurement, flocculant addition, settling in the three cell settling pond, and pumping water from the settling basin to the historic discharge channel. More details regarding the water and solids management system are provided in Section 5.

- Reconnaissance of the mountainside above the Red and Bonita workings was performed by EPA and DRMS. There were no indications of any overlying workings or other features connecting the underground workings to the surface.

4 PACKER TEST

Reconnaissance and mapping of the underground workings of the Red and Bonita mine conducted during 2012 and 2013 identified a location 265 feet in from the mine portal as the ideal location for a water impounding concrete bulkhead. The rock at this location is intensely jointed, and although the joints are tight, it was determined that packer testing to determine the permeability of the joint was a prudent step in the bulkhead feasibility evaluation (DRMS 2014).

4.1 PACKER TEST METHOD

Cumulative packer tests were performed on September 9 and 10, 2014 to evaluate the in situ hydraulic permeability of the shallow rock at the potential bulkhead location. The packer test was conducted by drilling a borehole into the rock, inserting a plug (packer) into the borehole, injecting water behind the plug, and measuring the amount of water needed to maintain a steady pressure. A greater amount of water required indicates greater hydraulic conductivity than if only a small amount of water is required to maintain the pressure. The detailed packer test description, procedure, and equipment list are included in Appendix D. The following work was completed for the 2014 packer test.

1. Two 10.5 foot deep 2.25-inch diameter boreholes were drilled, one on each side of the mine, at 265 feet into the mine and an additional two boreholes were drilled at 275 feet into the mine (Figures 2 and 3).

2. Boreholes were flushed with clean water supplied by pump from a 255 gallon tote located outside of the mine.

3. The packer system was pre-tested outside the mine prior to start of the packer test.

4. The water line (consisting of water tank, pump, hoses, pressure gauges, valves, flow meter and connectors) was set up. The water line was observed for leakage.

5. The air supply (consisting of a pressurized air tank, gauge, hoses, and connectors) was set up.

6. The single packer assembly with open bottom was connected to the water line and air supply.

7. The packer element was inserted 48 to 50 inches into the borehole.

8. The packer gland was slowly inflated to a working pressure of 200 psi to seal the element against the borehole wall. The air supply line was monitored for 2 minutes to ensure the air system was not leaking.

9. Water was injected up to a pressure of 100 psi into the void between the packer element and the terminus of the borehole.

10. The flow rate of water to maintain a pressure of 100 psi was recorded regularly during the test. The test was operated for a minimum of 15 minutes except in the southeast borehole where packer air pressure was lost 6 minutes into the test.

11. Water injection flow rates and pressures were observed until consistent readings were taken to represent steady-state flow.

12. The water line was depressurized, then the air line was de-pressurized, and the packer was removed from the borehole.

13. The test was repeated in the remaining three holes.

14. Due to the positive results (relatively low flow of water required to maintain 100 psi pressure behind the packer), only one test was performed in each borehole. If the initial test had required a significant amount of water to maintain 100 psi, the test would have been repeated with the packer inserted an additional 2 to 4 feet into the borehole.

4.2 PACKER TEST RESULTS

The packer test data and results are shown below. The calculations and conclusions are presented in a DRMS memorandum (DRMS 2014b) that is provided in Appendix C and summarized below.

Location	Distance	Length of test section	Radius of Test hole	Water Consumptio	Test duration	Water Pressure	Secondary Permeability Index (SPI) (liters per

	into Mine	(meters)	(meters)	n (liters)	(seconds)	(meters of head)	second per square meter)
Northeast	275 feet	2.13	0.0254	0.051	900	60.09	Relatively Impermeable
Southeast	275 feet	2.13	0.0254	0.4725	360	70.59	Relatively Impermeable
Northwest	265 feet	2.13	0.0254	16.88	900	69.62	1.54×10^{-14}
Southwest	265 feet	2.13	0.0254	4.35	900	68.92	4×10^{-15}

The rock encountered at 265 feet and 275 feet into the Red and Bonita Mine is Class A as defined by Azimian (2013). Class A rock is impermeable and the best class of rock that does not need improvement. Based on these results and the proximity of a free rock face to the test locations, formation grouting prior to bulkhead installation will not be necessary.

5 WATER AND SOLIDS MANAGEMENT

Water management was designed to maintain the mine discharge at ambient conditions while mine entry operations were conducted. While some reduction in the dissolved metals was achieved, the primary goal was to remove the suspended solids from the adit. During 2013, the water and solids management system included sodium hydroxide addition in the portal pond, 6-inch piping to carry water from the mine to the settling basin, injection ports for polymer and flocculant addition, a three cell settling basin divided by 2-foot baffles, a multi-media filtration system, and filter bags. Clarified water from the settling basin was pumped to either the filtration system or filter bags. Components of the system are described below and shown on Figure 4.

5.1 WATER AND SOLIDS MANAGEMENT - 2013

The water and solids management system consisted of the following components, starting with discharge from the mine and ending with discharge to the historic flow path to Cement Creek.

1. Water flowed from the mine into the portal pond.
    a. Note: Large volumes of particulates were discharged during mine entries and accumulated in the portal pond, diminishing pond capacity. To correct this, the water was manually agitated to move the solids into the water and solids management system.
2. 25% sodium hydroxide, stored on a flatbed trailer in four 375-gallon totes, was pumped to the downstream end of the portal pond using a chemical injection pump and flexible hose. The initial injection rate was 1.25 liters per minute (L/min), but the caustic addition rate was adjusted as needed to maintain pH greater than 5.5. A generator was used to power the sodium hydroxide pump. When the pump was inadequate to increase pH above 5.5, sodium hydroxide was added manually using 1-gallon jugs. A 55-gallon barrel of potable water was configured as an emergency shower in the event of sodium hydroxide exposure.
3. A 14-inch PVC pipe transported water to the top edge of waste rock dump. A pipe reducer with a 6-inch manifold was used to direct water either into a 6-inch piping system or down the face of the waste rock dump. During mine entries, water was directed into the piping system. After mine water clarified at the end of the day, water was directed down the face of the waste rock dump and into the historic flow path to Cement Creek.

4. A port for the pH meter was installed in the manifold. pH was monitored with a Horiba water quality meter that was calibrated daily.

5. 6-inch aluminum piping carried water from the top of the waste rock dump to a small crosscut road near the bottom of the waste rock dump. Aluminum piping was used on the steepest slopes due to its strength, light weight, and ease of assembly. The aluminum pipe was connected to 6-inch PVC pipe at the crosscut road.

6. LBP polymer, stored in a 330-gallon tank on the crosscut road, was pumped to the water via tubing into an injection port in the PVC pipe. The initial injection rate was 0.11 L/min but the rate was adjusted as needed to enhance settling in the downstream settling pond. A generator was used to power the LBP polymer pump. The LBP polymer significantly increased the efficiency of the Chitosan flocculant, reducing settling time and increasing water clarity

7. 6-inch PVC piping was routed in a serpentine pattern to enhance mixing of the polymer and slow the water. The serpentine sections were made by connecting 18-inch pipe segments using right angle joints.

8. Two 6900-gallon emergency storage tanks (approximately 45 minutes of water inflow at 300 gpm) were staged on a platform at the north end of the waste rock dump base. The tanks were plumbed into the 6-inch piping system via a two valve Y manifold. The backup tanks may have provided storage for the discharge from the mine in the event of equipment failure and storage capacity in the pond was exceeded. The emergency storage tanks were not used.

9. Chitosan flocculant, stored in a 330-gallon tank at the north base of the waste rock dump, was pumped with a chemical injection pump through tubing into an injection port. Chitosan flocculant was used because it is a naturally biodegradable material that freely binds with the sludge and is completely retained with the sludge in the multi-media filtration system without clogging. The initial addition rate of 0.063 L/min was varied as needed to enhance settling in the downstream settling pond. A generator was used to power the pump.

    a. High altitude, cold temperatures and the high viscosity of the Chitosan flocculant caused problems for the chemical injection pump, the pump rate slowed even more when the flocculant was cold. The flocculant was diluted with water to make a 50% solution that was less viscous than pure flocculant.

10. Water was piped to the settling pond via 6-inch PVC piping.

    a. Straight pipe to the ditch adjacent to CR53 at the base of the waste rock dump

    b. Serpentine pipe then straight PVC pipe in the ditch (see item #6)

    c. Pipe under CR53 to the settling pond

11. Water flowed through a 6-inch flexible hose and a float mounted diffuser into the north end of the settling pond. The diffuser was used to aerate the water, prevent flowing water from damaging the pond, and enhance mixing of flocculant and polymer.

12. A settling pond (90 feet by 45 feet at the top of the berm and 33 feet by 45 feet at the toe of the berm with two three-foot high baffles) was used for solids settling (Figure 5). Solids settled to the

bottom leaving a layer of clear water on the surface. The pond with free-board was designed to hold about 6 hours of mine water inflow based on an estimated inflow rate of 300 gpm; however, the pond was operated at less than the calculated volume (water was pumped from the pond prior to reaching the full design depth). The pond was lined with geotextile fabric.

   a. Note: Solids removal in the pond system was difficult due to the steep slopes and the presence of the geotextile. Positioning the pond for easier access would be helpful for future events.

   b. The baffles were intended to be underwater; however, settling was greatly improved when the settling pond was operated as a 3 cell unit. Increasing the elevation of the baffles would improve settling.

13. Clarified water from the southern end of the settling pond was pumped through a floating strainer and 4-inch flexible hose connected to a 820 gpm, 4 inch diameter diesel powered water pump with a 4-inch flexible hose. Water was pumped to the multi-media filtration system during the mine entry operations. As final pond decanting occurred the water was pumped through filter bags.

    a. A 450 gpm 3-inch diesel powered water pump was available to provide redundancy in the event the 4-inch pump failed. A two valve manifold was positioned between the pond and the pumps so that either pump could draw water from the pond as needed.

    b. A three valve manifold diverted the water to the multi-media filtration system, filter bags, or the historic discharge path to Cement Creek.

14. Water was pumped to a two-stage multi-media filtration system. The first stage was a 1000 gpm series of four stainless steel tanks containing 19 cubic feet of sand and gravel. The second stage consisted of bridged 400 and 1000 gpm stainless steel tanks containing multiple 10 micron size filter bags. The resulting water was as clear or clearer than undisturbed adit discharge.

15. A backup filtration system was connected to the three valve manifold previously described. 4-inch flexible hose was linked between the three valve manifold to a four valve 6 inch PVC manifold which individually controlled water flow to four backup Dandy Dewatering Bags™. The backup system provided redundancy in the event of an emergency shutdown of the primary system but was not activated during this project.

16. Discharge to historic flow path to Cement Creek

5.2 WATER AND SOLIDS MANAGEMENT - 2014

The following system was used to collect solids during 2014 mine entries.

1. Sodium hydroxide, contained in a 375 gallon tote, was gravity fed to the downstream end of the portal pond. The initial addition rate of 1.25 L/minute was adjusted based on pH readings at the base of the waste rock dump.

   a. Note: It is important to maintain flexibility in chemical addition rates due to the high variability in pH and solids content of water discharged during mine entries.

   b. The pumps used for chemical injection during 2013 mine entries were not reliable in providing a safe, consistent flow of sodium hydroxide. Peristaltic pumps would be more effective for chemical addition and should be able to achieve adequate flow if multiple units are available for peak feed rates.

2. Water flowed down the northern face of the waste rock dump. Sandbags were placed to direct flow to the northernmost section of the typical flow path.

3. pH was measured with a Horiba water quality meter placed in the active flow path near the base of the waste rock dump immediately upstream of the flocculant addition point. The target pH was 7, with a tolerance from 5.5 to 8. The initial sodium hydroxide addition rate was 0.3 L/min, but the rate was adjusted as needed to achieve the target pH. It was noted that when pH increased to 10 or greater, the water got a greenish tinge.

4. Brennfloc, dissolved in water at a concentration of approximately 1 gram/liter, was gravity fed via a 2-inch hose from a 375 gallon plastic tote to the active flow path at the base of the waste rock dump. The initial feed rate was 1 L/min, but flow was adjusted as needed to achieve settling in the settling pond. When full flow gravity feed was not adequate to achieve settling, solid Brennfloc was added in the ditch on the east side of CR53.

   a. Note: While Brennfloc dissolved in water was most effective in settling water during cone and bucket tests, addition of particulate Brennfloc promoted better settling during full scale operation. It would be helpful to find a mechanized means to add particulate Brennfloc, a fine granular material.

5. Water flowed south in the ditch along the east side of CR53, the typical flow path, to a headgate made of plywood that directed water into a 12-inch PVC pipe that crossed under CR53 to the settling pond. [When the system was not being operated, the headgate was opened and water flowed in the typical flow path toward Cement Creek.]

6. Water flowed through the pipe into the north cell of the settling pond. The settling pond was the same as was used during 2013; however, the baffles were elevated using a combination of hay bales and staked geofabric.

   a. Note: Water flowed directly from the 12-inch pipe into the pond. Use of a diffuser or other means to reduce the velocity of water entering the pond would allow more effective settling.

   b. Note: The staked geofabric was somewhat effective in raising the effective height of the baffles. The hay bales were more effective in raising the effective height of the baffles.

   c. Note: Increasing the effective height of the baffles and creating weirs to cause serpentine flow in the settling pond would improve settling.

7. Water was pumped from the southern cell of the settling pond and discharged along the historic flow path for Red and Bonita Mine discharge.

8. Settling pond system discharges were periodically monitored for pH, conductivity, and turbidity.

9. Filter bags were available for additional filtration; however, when the turbidity of discharge from the filter bags was not significantly less than that pumped directly from the southern cell of the settling pond, the use of filter bags was discontinued.

10. At the end of the day when water in the mine was not being disturbed, the pH leveled at approximately 6 and water flowing down the waste rock dump face appeared clear.

6 SAMPLING AND ANALYSIS

6.1 SAMPLE COLLECTION

Five surface water samples plus one duplicate sample were collected from outside the mine during 2013 and submitted for total and dissolved metals analysis at the EPA Laboratory in Golden, Colorado. Surface water sample locations are shown on Figure 6.

- RBSW01_08072013 was collected from the pool outside the mine portal (portal pool) before any mine work began in order to provide baseline data for future comparison. This site is known as CC-03C in site-wide monitoring efforts.

- RBSW02_080913 and RBSW02_08142013 were collected from the multi-media filtration discharge point to represent post-filtration water quality.

- RBSW03_08072013 was collected from Cement Creek downstream of the Red and Bonita inflow prior to mine entry.

- RBSW03_08142013 was collected from the adit pool (CC-03C) approximately 3 hours after the completion of the last 2013 mine entry to represent post-entry mine discharge water quality and for comparison to the baseline sample.

- Sample RBSW99_080913 was collected as a duplicate of sample RBSW02_080913.

Due to a delay in filtration and preservation, the dissolved metals analytical results from samples collected on August 7 and August 9 should be interpreted with caution.

Three mine water samples were collected by from the Red and Bonita Mine during the 2013 mine entry. Mine water sample locations are shown on Figure 3.

- RBMW01_08132013 was collected 275 feet into the mine from a drift to the right flowing at approximately 40 gpm.

- RBMW02_08132013 was collected 764 feet into the mine from a stope in the main channel flowing at approximately 200 gpm.

- RBMW03_08132013 was collected 764 feet into the mine from a channel entering from the left flowing at approximately 20 gpm.

One solid sample (RB071913-SO01) was collected from the base of the settling pond prior to use of the pond during 2013. This sample represents the total metals concentrations in the solids discharged during 2012 site activities.

Water samples were not collected during 2014. Settling pond solids were collected in a 5-gallon bucket after the first day of settling pond operations, covered with geotextile, and placed under a tree south of the waste rock dump. The sample will be used to assist in determining the best means of handling and disposing solids left in the ponds after the 2014 mine entry efforts.

6.2 SAMPLE RESULTS AND DISCUSSION

The total and dissolved metals concentrations for the portal pool and settling system effluent sample are shown on Table 2. The total and dissolved metals concentrations for the in-mine samples and the portal pool are shown on Table 3. The portal pool samples are shown on both tables for ease of comparison. The total metals analytical results for the pond solids sample are provided in Table 4. A comparison of duplicate samples is shown on Table 5.

6.2.1 Portal Pool Before and After Mine Entries

Comparison of the two samples collected from the portal pool before and after mine entries indicates that there was a slight increase in the concentration of total metal analytes after the entries were complete. This may be due to collecting the post-entry sample only three hours after the last entry and the residual presence of suspended solids from the mine entry. Dissolved metals concentrations were not compared due to delayed filtration and preservation of the dissolved metals samples collected on August 7 and 9.

6.2.2 In-Mine Water Analytical Results

The total and dissolved metals analytical results for samples collected inside the mine and immediately outside the mine were compared.

- The sample collected from 744 foot drift to the left (20 gpm) had lower total and dissolved aluminum, dissolved iron, and total and dissolved zinc concentrations compared to the other in-mine samples and samples collected at the portal.
- The samples from the drift 275 feet into the mine, with flow approximately 40 gpm, had higher aluminum and cadmium concentrations than the other samples.

The load of contaminants from each source was calculated assuming flows shown on Table 3, where load is the mass of contaminant discharged per day (concentration times flow).

	2+75 drift to right		7+64 Main		7+64 drift to left	
	Flow (gpm)	**% of Total Flow**	**Flow (gpm)**	**% of Total Flow**	**Flow (gpm)**	**% of Total Flow**
	40	15%	200	77%	20	8%
	Load (pounds/day)	**Percent of Total Load**	**Load (pounds/day)**	**Percent of Total Load**	**Load (pounds/day)**	**Percent of Total Load**
Cadmium	0.044	45%	0.049	50%	0.0048	5
Iron	21.5	10%	180	88%	4.01	2
Zinc	8.4	17%	40.6	80%	1.52	3

The relative load from a source indicates the importance of that source. While the drift 275 feet into the mine represents only 15% of the flow, it represents 45% of the cadmium load and 17% of the zinc load in the mine discharge. The significant contaminant contributions from the drift at 275 feet show the importance of placing the bulkhead where it will contain water from that source.

6.2.3 Water and Solids Management System Discharge Water Results

Two water samples were collected from the water and solids management system discharge, one on August 9 and one on August 14, 2013 (Table 2). Total metal concentrations of metals were similar to or lower on August 14 than on August 9.

Total metals concentrations in the treatment system discharge samples were compared against concentrations in the portal pool samples. Most metal concentrations were similar in the portal pool and the treatment system discharge, but total aluminum and iron were lower in the post-filtration samples. The total sodium concentration was higher in the post-filtration samples.

The sample results indicate the system was effective in minimizing the impacts from mine entries.

6.2.4 Solids Sample Results

Metal concentrations in the solids left in the settling pond from 2012 efforts (Table 4) can be compared to the TCLP sample results from 2012 (Table 1).

6.2.5 Duplicate Sample Results

The duplicate results were compared using relative percent difference (RPD) (Table 5). The RPD ranged from 0 to 10.6%, well within the limits established in the Sampling and Analysis Plan.

7 REFERENCES

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FIGURES

TABLES

TABLE 1
2012 Toxicity Characteristic Leaching Procedure (TCLP) Analytical Results

Analyte	Concentration (mg/L)	RCRA Limit (mg/L)
Arsenic	0.004	5
Barium	0.067 U	100
Cadmium	0.0311	1
Chromium	0.004 U	5
Lead	0.118	5
Mercury	0.0000830	0.2
Selenium	0.0103	1
Silver	0.002 U	5

mg/L milligrams per liter
Limits from 40 CFR 261.24
Analytical results from CompuChem as reported in UOS 2012b.

TABLE 2
Surface Water Analytical Results

Analyte	RBSW01_08072013		RBSW02_08092013		RBSW02_08142013		RBSW03_08072013		RBSW03_08142013	
	Portal Pool Prior to Mine Entries		Filtration Discharge		Filtration Discharge		Cement Creek Downstream of Red and Bonita Inflow		Portal Pool 3 Hours after Final Mine Entry	
	8/7/2013		8/9/2013		8/14/2013		8/7/2013		8/14/2013	
	Dissolved* (µg/L)	Total (µg/L)	Dissolved* (µg/L)	Total (µg/L)	Dissolved (µg/L)	Total (µg/L)	Dissolved* (µg/L)	Total (µg/L)	Dissolved (µg/L)	Total (µg/L)
Aluminum	4840 D	5950 D	2220 D	2260 D	371 JD	429 JD	3130 D	2800 D	3940 D	4420 D
Antimony	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
Arsenic	1000 UJ	1000 U	1000 UJ	1000 U	1000 UJ	1000 U	1000 UJ	1000 U	1000 UJ	1000 U
Barium	50 U	50 U	50 U	50 U	50 U	50 U	20 JD	21 JD	50 U	50 U
Beryllium	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Cadmium	30.5 JD	31.3 JD	39.6 JD	37.7 JD	24.2 JD	21 JD	60 U	60 U	31.3 JD	31.6 JD
Calcium	425000 D	417000 D	422000 D	419000 D	427000 D	417000 D	129000 D	130000 D	417000 D	427000 D
Chromium	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Cobalt	119 D	108 D	114 D	107 D	83.7 D	90.6 D	27.4 JD	24.8 JD	110 D	107 D
Copper	50.4 D	76.5 D	37.6 D	34 D	30 U	30 U	140 D	144 D	30 U	43.7 D
Hardness	1170 D	--	1160 D	--	1170 D	--	365 D	--	1150 D	--
Iron	90400 D	93300 D	63200 D	61500 D	38000 D	40600 D	15500 D	15700 D	55600 D	103000 D
Lead	131 JD	290 D	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Magnesium	26000 D	26000 D	25800 D	25900 D	25900 D	25600 D	10100 D	9970 D	25700 D	26300 D
Manganese	33600 D	33300 D	32300 D	32200 D	32000 D	31500 D	9140 D	8950 D	33200 D	34200 D
Mercury	NA	0.2 U	NA	0.2 U	NA	0.2 U	NA	0.2 U	NA	0.2 U
Molybdenum	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Nickel	84.6 JD	73 JD	82.4 JD	67.8 JD	58.8 JD	57.9 JD	100 U	100 U	72.3 JD	70 JD
Potassium	10000 U	10000 U	10000 U	10000 U	10000 U	10000 U	10000 U	10000 U	10000 U	10000 U
Selenium	1000 U	917 JD	1000 U	1000 U	610 JD	1000 U	1000 U	1000 U	1000 U	754 JD
Silver	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Sodium	7980 JD	8170 JD	57200 D	58200 D	79000 D	78600 D	3030 JD	3000 JD	8040 JD	8220 JD
Strontium	4850 D	4870 D	4740 D	4730 D	4820 D	4780 D	1350 D	1340 D	4820 D	4930 D
Thallium	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Vanadium	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Zinc	16000 D	15900 D	15600 D	15300 D	8740 D	8600 D	5590 D	5430 D	15600 D	16200 D

J	The reported value was obtained from a reading that was less than the contract required quantitation limit but greater than or equal to the method detection limit.
U	The analyte was not detected at the method detection limit
D	The reported value is from a dilution
NA	Not Applicable
µg/L	micrograms per liter
gpm	gallons per minute
*	The analytical results for dissolved samples collected on August 7 and 9, 2013 should be used cautiously due to a filtration/preservation error.

TABLE 3
Mine Water Analytical Results

Analyte	RBMW01_08132013		RBMW02_08132013		RBMW03_08132013		RBSW01_08072013	
	2+75 Drift to Right (40 gpm)		7+64 Stope (200 gpm)		7+64 Drift to left (20 gpm)		Portal Pool before Mine Entries	
	Total (µg/L)	Dissolved (µg/L)	Total (µg/L)	Dissolved (µg/L)	Total (µg/L)	Dissolved (µg/L)	Total (µg/L)	Dissolved (µg/L)
Aluminum	11,400 D	11,100 D	3760 D	3430 D	399 JD	410 JD	5950 D	4840 D
Antimony	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Arsenic	600 U	600 UJ	600 U	600 UJ	600 U	600 UJ	600 U	600 UJ
Barium	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Beryllium	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Cadmium	91.6 D	92 D	20 U	20.6 JD	20 U	20 U	31.3 JD	30.5 JD
Calcium	478,000 D	478,000 D	446,000 D	437,000 D	329,000 D	324,000 D	417,000 D	425,000 D
Chromium	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Cobalt	126 D	131 D	113 D	120 D	62.7 D	67 D	108 D	119 D
Copper	33.7 D	30.1 D	20 U	20 U	21.3 JD	20 U	76.5 D	50.4 D
Iron	87,100 D	44,700 D	98,700 D	75,000 D	72,800 D	16,700 D	93,300 D	90,400 D
Lead	100 U	100 U	100 U	100 U	100 U	100 U	290 D	131 JD
Magnesium	32,600 D	32400 D	25700 D	25200 D	26300 D	25800 D	26000 D	26000 D
Manganese	28,400 D	28400 D	35400 D	35000 D	32300 D	31700 D	33300 D	33600 D
Mercury	0.1 U	NA	0.1 U	NA	0.1 U	NA	0.1 U	100 U
Molybdenum	107 JD	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Nickel	89 JD	110 D	79 JD	77.7 JD	50 U	50 U	73 JD	84.6 JD
Potassium	2500 U	2500 U	2760 JD	2500 U	2500 U	2500 U	2500 U	2500 U
Selenium	600 U	600 U	600 U	600 U	600 U	600 U	917 JD	600 U
Silver	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Sodium	9550 JD	9380 JD	7920 JD	7680 JD	10300 D	9970 JD	8170 JD	7980 JD
Strontium	5550 D	5540 D	5160 D	5040 D	3550 D	3490 D	4870 D	4850 D
Thallium	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Vanadium	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Zinc	17,500 D	17,400 D	17,100 D	16,900 D	6520 D	6350 D	15,900 D	16,000 D

J The reported value was obtained from a reading that was less than the contract required quantitation limit but greater than or equal to the method detection limit.
U The analyte was not detected at the method detection limit
D The reported value is from a dilution

NA	Not Applicable
µg/L	micrograms per liter
gpm	gallons per minute

TABLE 4
Total Metals Analytical Results - Settling Pond Solids

Sample ID	RB071913-SO01	
Sample Date	7/19/2013	
Analyte	Chemical Abstract System Number	Concentration (mg/kg)
Aluminum	7429-90-5	3280
Antimony	7440-36-0	100 U
Arsenic	7440-38-2	67.1 J
Barium	7440-39-3	12.2
Beryllium	7440-41-7	5 U
Cadmium	7440-43-9	3.21 J
Calcium	7440-70-2	2630
Chromium	7440-47-3	5 U
Cobalt	7440-48-4	5 U
Copper	7440-50-8	282
Iron	7439-89-6	110,000
Lead	7439-92-1	787
Magnesium	7439-95-4	339
Manganese	7439-96-5	195
Molybdenum	7439-98-7	20 U
Nickel	7440-02-0	10 U
Potassium	7440-09-7	411
Selenium	7782-49-2	100 U
Silver	7440-22-4	11
Sodium	7440-23-5	1000 U
Strontium	7440-24-6	28.6
Thallium	7440-28-0	50 U
Vanadium	7440-62-2	16.4
Zinc	7440-66-6	1520

J The reported value was obtained from a reading that was less than the contract required quantitation limit but greater than or equal to the method detection limit.
U The analyte was not detected at the method detection limit
mg/kg milligrams per kilogram dry weight

TABLE 5
Duplicate Sample Results

	RBSW02_08 092013	RBSW99_08 092013	Relative Percent Difference	RBSW02_08 092013	RBSW99_08 092013	Relative Percent Difference
	Dissolved (µg/L)	Dissolved (µg/L)		Total (µg/L)	Total (µg/L)	
Aluminum	2220	2240	0.9%	2260	2220	1.8%
Antimony	1000 U	1000 U	--	1000 U	1000 U	--
Arsenic	1000 UJ	1000 UJ	--	1000 U	1000 U	--
Barium	50 U	50 U	--	50 U	50 U	--
Beryllium	50 U	50 U	--	50 U	50 U	--
Cadmium	39.6	37.1	6.5%	37.7	35.5	6.0%
Calcium	422000	414000	1.9%	419000	417000	0.5%
Chromium	50 U	50 U	--	50 U	50 U	--
Cobalt	114	107	6.3%	107	114	6.3%
Copper	37.6	41.8	10.6%	34	34.6	1.7%
Hardness	1160	1140	1.7%	NA	NA	--
Iron	63200	60200	4.9%	61500	60400	1.8%
Lead	250 U	250 U	--	250 U	250 U	--
Magnesium	25800	25700	0.4%	25900	25900	0
Manganese	32300	31800	1.6%	32200	32200	0
Mercury	NA	NA	--	0.2 U	0.2 U	--
Molybdenum	200 U	200 U	--	200 U	200 U	--
Nickel	82.4	80.4	2.5%	67.8	65	4.2%
Potassium	10000 U	10000 U	--	10000 U	10000 U	--
Selenium	1000 U	704	--	1000 U	1000 U	--
Silver	100 U	100 U	--	100 U	100 U	--
Sodium	57200	57300	0.2%	58200	58200	0.0%
Strontium	4740	4700	0.8%	4730	4780	1.1%
Thallium	500 U	500 U	--	500 U	500 U	--
Vanadium	500 U	500 U	--	500 U	500 U	--
Zinc	15600	15400	1.3%	15300	15200	0.7%

J The reported value was obtained from a reading that was less than the contract required quantitation limit but greater than or equal to the method detection limit.
U The analyte was not detected at the method detection limit
D The reported value is from a dilution
NA Not Applicable
µg/L micrograms per liter
RPD Relative percent difference (C1-C2)/[(C1+C2)/2]*100%

APPENDIX A
PHOTOGRAPHIC DOCUMENTATION

APPENDIX B
WATER AND SOLIDS MANAGEMENT

APPENDIX C
DRMS REPORTS

APPENDIX D
PACKER TEST

APPENDIX E
LABORATORY ANALYTICAL RESULTS